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30 Foot Lightweight Telescopic Mast, AB-653(XE-1)/G, Phase I, II, III
Report No. 3 Contract No. DA 36-039 AMC-03309 (E)
DA Project No. 3B24-01-003 Final Report
1 July 1963 - 30 June 1964

U. S. Army Electronics Research and Development
Laboratory Fort Monmouth, New Jersey

AMERICAN MACHINE & FOUNDRY COMPANY
ADVANCED PRODUCTS GROUP
Whiteford Road
YORK, PENNSYLVANIA 17402

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U. S. Army Electronics Research and Development
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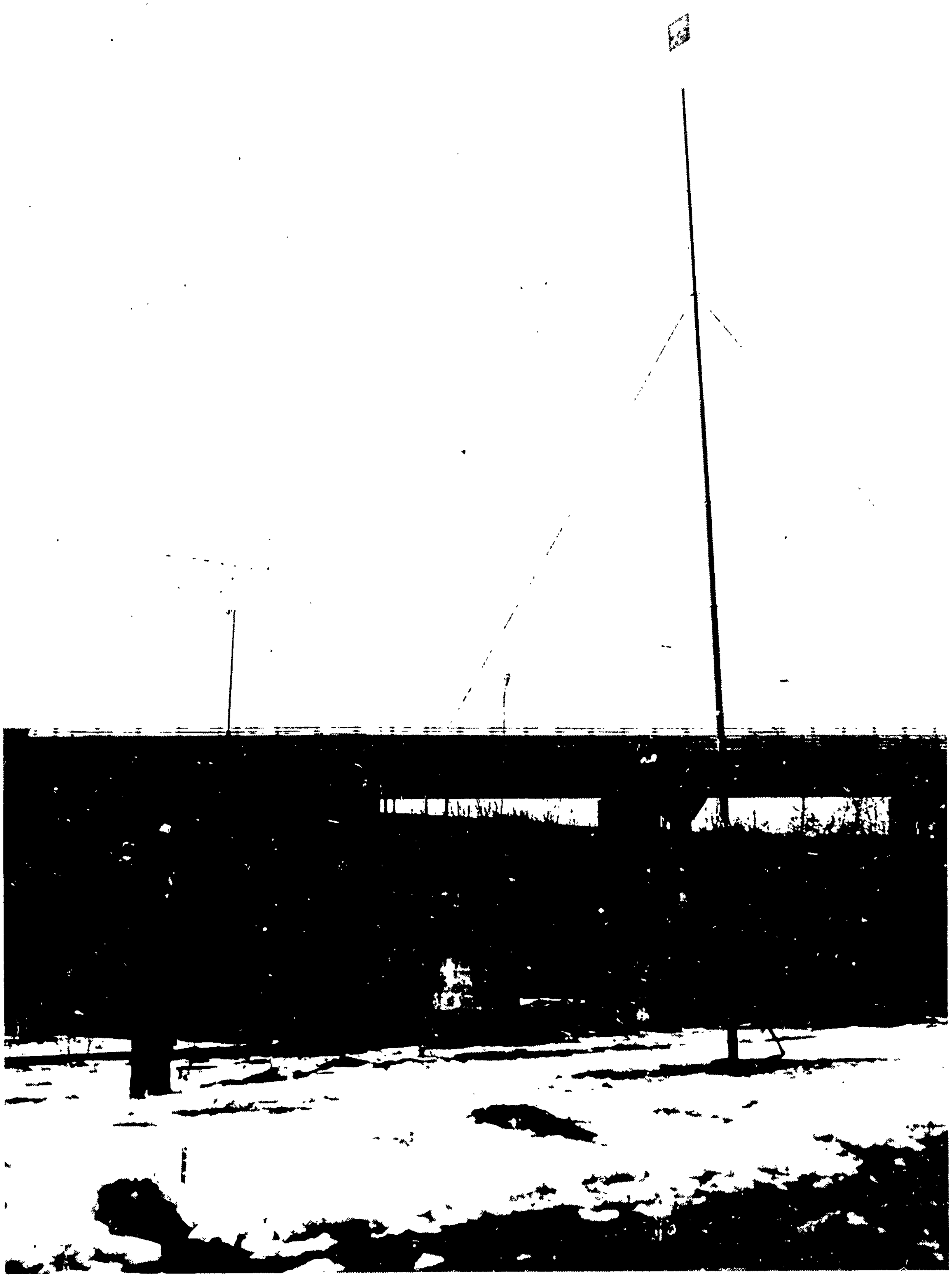
Signal Corps Technical Requirements
SCL 4549
Development of a Lightweight Telescopic
Mast capable of quick erection by two men.

Prepared by Lewis V. Smith Jr.
Lewis V. Smith, Jr.

AMERICAN MACHINE & FOUNDRY COMPANY
ADVANCED PRODUCTS GROUP
, Whiteford Road
YORK, PENNSYLVANIA 17402

MAST PACKAGED



MAST EXTENDED

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1. PURPOSE

This report represents the final report of Contract DA 36-039 AMC-03309 (E) 30 Foot Lightweight Telescopic Mast for U. S. Army Electronics Materiel Agency, Fort Monmouth, New Jersey. Included are the results from all three phases of the program. Phase I included the design plan, test, plan, and technical reports. Phase II included the manufacture of a preliminary engineering test model and testing to determine the suitability of the design. It also included the manufacture of three engineering test models with modifications based on testing. Phase III covered the manufacturing data.

The purpose of the contract was to design a lightweight mast (design goal 15 pounds) which can be stored in a package no longer than 48 inches.

In addition, the following requirements were to be met:

1) Type Mast - sectionalized, telescopic.
2) Manually erectable by 1 man while stabilized or 2 men in 3 minutes while a 20 mph wind is blowing.
3) Mechanical joints shall automatically lock when fully extended and shall permit removal of any individual mast section without complete disassembly of the mast.
4) Survival shall be with a 10 pound antenna on top having 1 square foot of projected area while a 70 mph wind is blowing.

2. ABSTRACT

A preliminary engineering test model of a 30 Foot Lightweight Telescopic Mast has been built and tested. Modifications, based on engineering test, have been made to the design and the three engineering test models manufactured. The final weight of the mast is about 19.5 pounds. The mast is capable of erection by 2 men in a 20 mph wind and with the base stabilized it can be erected by 1 man.

<u>Conclusions.</u>

1) A 30 foot guyed mast with its case can be built from aluminum and fiberglass and weigh less than 20 pounds.

2.) A telescopic mast is difficult for 1 man to erect in a 20 mph wind when it is higher than 22 feet.

3.) A telescopic mast resists extension under wind load in proportion to the wind velocity. This mast which can be easily extended with no wind acting, resists the efforts of 2 men in winds about 20 mph due to a wedging action and friction between the mating sections.

4.) An aluminum-fiberglass structure can be very effective when the materials can be located to take advantage of their inherent properties.

3. CONFERENCES

The following conferences were held with the Signal Corps on the dates indicated.

a. July 25, 1963 at Fort Monmouth.

Organizations: Signal Corps
AMF

Subject discussed: Specification SCL 4549
Delivery
Organizations

Conclusions:
1) Minimum weight is important.
2) All materials should be considered.
3) 2 months additional time is required by Signal Corps for evaluation tests.
4) Vehicle mounting requires erection from storage position.
5) Anchorage in difficult ground is not part of problem.
6) Last three units should have interchangeable parts.
7) The 200 cycle erection test does not have to be continuous.
8) The joint should provide a positive torsional lock.

b. August 16, 1963 at AMF Stamford.

Organizations: Signal Corps
AMF

Subject discussed: Design review of 30 Foot Lightweight Mast.

Conclusions: Preliminary concurrence on design approach.

c. September 3, 1963 at Fort Monmouth.

Organizations: Signal Corps
AMF

Subject discussed: Design Plan

Conclusions:
1) Model joint should be tested for torsion.
2) Cap should not lie in mud.
3) Fittings should be re-examined with respect to bounce test.
4) Cycling test can be performed with simulated wind.
5) Top load should be simulated.
6) Visual inspection and proper functioning established whether permanent deformation has taken place after static load test.

d. October 10, 1963 at AMF Stamford.

Organizations: Signal Corps
AMF

Subject discussed: Design drawings review
Test Plan review.

Conclusions:
1) Design plan verbally approved.
2) Several details to be revised.
3) Drawings approved for fabrication.
4) Signal Corps inspection representative to be designated.
5) ECN's on first unit do not require Signal Corps approval since drawings must be approved for units 2, 3, and 4.
6) Revisions to test are to be made and approval will be granted.

e. February 14, 1964 at Stamford.

Organizations: Signal Corps.
AMF

Subject discussed: Modifications resulting from tests.

Conclusions:

1) Clearance between case and first tube should be checked to prevent balls from wedging in between.

2) Finish on case should be improved.

3) Improve hinge bar on base.

4) Close bottom of top tube to hold stakes.

5) Check fit of tubes.

6) Fiberglass taper should be longer.

7) Joints should be reinforced.

8) Mastic should be used in joints rather than neoprene strips.

9) Interference between screws and tubes should be eliminated.

10) More clearance should be obtained at joints by reducing total height by 2 inches and maintaining 48 inches length when closed.

11) Eliminate neoprene in top tube.

12) Change stake so clip will rest within the stake profile.

13) Reinforce guy reels and enlarge them so clips rest.

14) Guy length markers should be investigated to allow identification in the dark.

15) Optimize spring wire diameter of locking joint.

16) Slot length should be reduced in tube head.

17) Revise button design.

18) Study center pin for improvement.

f. March 10, 1964 at Fort Monmouth.

Organizations: Signal Corps
AMF

Subject Discussed: Deliver preliminary engineering test model of mast. Discuss test report and drawing changes.

Conclusions: Drawings will be acceptable with modifications shown.

g. March 25, 1964 at Fort Monmouth.

Organizations: Signal Corps
AMF

Subject Discussed: Signal Corps comments on drawings.

Conclusions: Drawings will be approved for manufacture with changes noted.

h. May 4, 1964 at Fort Monmouth.

Organizations: Signal Corps
AMF

Subject discussed: Delivered new bracket for jeep mounting. Discussed program.

Conclusions: Signal Corp requested that one of three engineering test models receive a bounce test in addition to the one performed.

Conferences with fiberglass fabricators and aluminum spinning specialists were held with the Warminister Fiberglass Company; Depew Manufacturing Corporation; Lamtex Industries, Inc.; Hercules Powder Company; Lunn Laminates, Inc.; Russell Reinforced Plastic Corporation and Garden State Metal Spinning and Stamping Corporation.

The following reports have been submitted to the Signal Corps:

1) Design Plan for 30 ft. Lightweight Telescopic Mast by Lewis V. Smith, Jr., September 1963
2) Quality Assurance Program and Test Plan and Procedure for Lightweight Telescopic Mast - 30 foot by S. Glassman, September 1963
3) 30 Foot Lightweight Telescopic Mast, Phase I, Report No. 1, Control No. DA 36-039 AMC-03309 (E) DA Project No. 3B24-

01-003 1st Quarterly Report 1 July - 30 September 1963

4) 30 Foot Lightweight Telescopic Mast, Phase II, Report No. 2, Contract No. DA 36-039 AMC-03309 (E) DA Project No. 3B24-01-003 2nd Quarterly Report 1 October 1963 - 31 January 1964

4. FACTUAL DATA.

The 30 foot telescopic mast as conceived and developed can be used to provide a means for supporting a 10 pound antenna 30 foot above ground. It was designed to allow vertical erection in forests and other places where overhead obstructions exist. When retracted it fits into a parachutist's drop bag. The mast which evolved from the design study has eight aluminum and one fiberglass telescopic section. The fiberglass section serves as a case to protect and store the guys, stakes and other parts during transit.

The mast may be erected in two modes; attached to the vehicle and acting as a cantilever structure when the wind does not exceed 20 mph, and on the ground supported by 3 guy ropes and surviving a 70 mph wind. Erection, however, should be performed when the wind is below 20 mph. The principal erection mode is when the guy ropes are used. The sequence of erection follows.

The cap will be removed by turning and pulling since it is retained by a bayonet type lock. The tube will be upended to discharge the stakes stored within. The center stake will be driven into the ground at the chosen site as the aluminum hinged plates are extended to rest on the ground. The three guy reels are then removed from their resting place in the cap. The first guy will be attached to the guy rim with its boat snap and the rope extended away from the stake to the first color mark on the rope. The mast should be laid next to the center stake. The stake will be driven in at this point and the guy rope attached to the stake. The reel which acts as a snubber will be set at the second color mark to establish a loose guy length for the erected position. This procedure is repeated for each of the other guys setting the stakes at an angle of approximately 120° with each other and center stake. The mast will then be set on the center stake in a vertical position after

extending the hinged arm at the base to receive the azimuth restraint stake. This stake should be driven through the arm into the ground to restrain the mast in azimuth while erecting it.

The first section of the mast should be withdrawn sufficiently to attach the antenna. The first section will then be extended full length until the spring clip engages. Each section in turn is extended in this fashion until the mast if fully extended. The mast is held vertical by the operators while extending the mast. When it is fully extended, the guy rope will be capable of supporting the mast while the operators go to each rope to adjust them to make the mast vertical and apply a small preload. The antenna may then be pointed by removing the azimuth restraint stake and rotating the mast with the arm and restaking.

Removal of the mast is the reverse of the erection procedure except that each joint must be disengaged by lifting the mast above the joint and rotating the spring knob in the direction which will spread the spring into the outer groove. The upper section can then be telescoped into the lower.

Erection from the vehicle is similar to the normal erection except the guys are not required in low winds. The vehicle should be located on level ground prior to erection. The cap and stakes should be removed and stored in the vehicle. After erection, azimuth adjustment may be made by loosening the upper vehicle clamp.

A 30 foot high mast could be a free standing cantilever. However, to minimize weight and to limit wind loads, the mast should be very slender and supported by guy wires. In this manner, a wide base can be provided with a small wind load. When a guyed mast receives a wind load, reactions are taken by the guys which have vertical components. These loads, in addition to the dead load of the antenna and the mast, combine to form a large vertical load. When this vertical load is sufficient to create significant additional bending moments and deflections above the bending due to

wind, a beam column exists. The stability of such a structure must be questioned. An analysis of the beam column 30 feet long indicated that lowering the guy attachment to the 25 foot level would give a balance of cantilever moment and beam column moment which would allow the lightest stable design.

Stability of the mast was tested by use of the Euhler column formula and moments resulting from beam column loads were obtained from Table 13:3 and formula 14:13 found in "Airplane Structures" by Niles and Newell, Vol. II, Third Edition. The wall thicknesses of the telescopic tubes were varied to obtain a constant moment of inertia to permit use of the tables. Any changes because of available sizes were on the side of safety.

Fiberglass and aluminum designs were carried through to compare net weight of the structure. The stability of the beam column is dependent on the EI of the mast section. In order to obtain equal designs, the EI of aluminum was equated to the EI of fiberglass. It was found that in order to be competitive in weight, the fiberglass would have to have a modulus of elasticity of 7,000,000 pounds per square inch. Figures 1 and 2 indicate the relative weights obtained in fiberglass and aluminum under these conditions. All calculations were submitted in the Design Plan. Aluminum was chosen since we could not be sure of obtaining a modulus of 7,000,000 psi in fiberglass.

AmF AMERICAN MACHINE & FOUNDRY COMPANY	CALCULATION SHEET	PAGE ___ OF ___

PROJECT	JOB ORDER NO.	CALCULATION SERIAL NO.
Extended Lengths		

Fiberglass $E = 7 \times 10^6$

$EI = 2 \times 10^6$ $\quad I = 0.286$

360″

Length	OD	ID	t	w = A(0.072)	Σw 12.87 W#/11	A = πDt A	I = πr³t I	S	D/t	S buckling
37	1.500		0.21	0.0711	2.92	0.99	0.286	0.382		
37½	1.75		0.136	0.0540	2.24	0.75	0.286	0.328		
42½	2.000		0.092	0.0417	1.94	0.58	0.286	0.286	22	33000 A 48000
42	2.250		0.064	0.0324	1.49	0.45	0.286	0.254	35	30000 58000
41½	2.500		0.047	0.0266	1.21	0.37	0.286	0.229	53	27000 46000
39	2.750		0.036	0.0223	1.01	0.31	0.286	0.207	76	24000 34000
38½	3.000		0.027	0.0180	0.80	0.25	0.286	0.190	111	20000 28000
38	3.250		0.021	0.0151	0.66	0.21	0.286	0.176	155	12,500
44	3.500		0.017	0.0137	0.60	0.19	0.286	0.163	206	24000

Σw 10.29

Length	t	w			I	S
37	0.105	0.0355	1.46	0.495	0.143	0.191
37½	0.068	0.0270	1.12	0.375	0.143	0.164

PREPARED BY	DATE
RVS	7/24
CHECKED BY	DATE

FORM 4134(10) REV. (3-63)

Figure 1 Chart of Fiberglass Weights

AMERICAN MACHINE & FOUNDRY COMPANY	CALCULATION SHEET	PAGE ___ OF ___

PROJECT	JOB ORDER No.	CALCULATION SERIAL No.
Extended Lengths		

AL. $EI = 10^7 (0.2) = 2 \times 10^6$

$E = 10^7$

$I = 0.2$

$\Sigma w = 12.35$ #

$\Sigma w = 9.87$ #

Total length: 360"

Length	OD	ID	t	$A(0.098)$ w #/"		$A = \pi D t$ A in²	$I = \pi r^3 t$ I in⁴	S in³	t	ω	A	I	S
37	1.500		0.15	0.0695	2.35	0.71	0.2	0.267	0.075	0.0347	1.42	0.35	0.1	0.133
$37\frac{1}{2}$	1.75		0.095	0.0546	2.12	0.52	0.2	0.229	0.0475	0.0255	1.06	0.26	0.1	0.114
$42\frac{1}{2}$	2.000		0.064	0.0392	1.82	0.40	0.2	0.200	t	ω	A	I	S
42	2.250		0.045	0.0313	1.44	0.32	0.2	0.178			0.040		
$41\frac{1}{2}$	2.500		0.033	0.0255	1.16	0.26	0.2	0.160			0.0264		
39	2.750		0.025	0.0215	0.97	0.22	0.2	0.145			0.018		
$38\frac{1}{2}$	3.000		0.019	0.0176	0.78	0.18	0.2	0.133			0.0133		
38	3.250		0.015	0.0147	0.65	0.15	0.2	0.123			0.0092		
44	3.500		0.012	0.0127	0.56	0.13	0.2	0.114			0.0064		

t_R

PREPARED BY	DATE
LVS	7/26
CHECKED BY	DATE

FORM 4124110I REV. (3-62)

Figure 2. Chart of Aluminum Weights

The special joint developed for the telescopic sections allows locking in any azimuth position, removal of any section without disturbing other sections and transmits torsion sufficient to keep the antenna heading in the direction pointed. Tests have been performed relative to the joint torsion and the results were submitted as an addendum to the Design Plan.

The design with calculated weight of 17 pounds, was completed and 29 drawings described the complete equipment. The drawings were approved by the Signal Corps and released to manufacturing.

The case and cap which are fiberglass were manufactured in the AMF Prototype shop.

The aluminum tubes had a bead spun into the ends by Garden State Metal Spinning and Stamping Corporation by a process developed in cooperation with AMF. The tooling for this has been kept to a minimum. It consists of a split collar for each tube size and one inside roller to deform the aluminum into the collar.

The mast, when stored, fits into the fiberglass base section which serves as a protective case and is covered by a fiberglass cap to protect the aluminum tubes from impact damage. The guys are made of dacron rope and are stored in the cap on three fiberglass spools. Guy and center stakes are stored within the smallest tube. The package is 48 inches long by 6-3/4 inches diameter at the widest point.

Two steel brackets are provided to allow for mounting to a jeep or weapons carrier. The mounting permits erection of the mast without guys for operation in winds of less than 20 mph.

The preliminary engineering test model was built after design approval. All of the drawn aluminum tubes were available in wall thicknesses close to the design size except for two tube sizes. These were purchased as thicker walls and were chemically milled in our laboratory to the size required. The flared section and the tube ends were formed by Garden

State Metal Spinning in New Jersey. The fiberglass was applied to the aluminum tubes and machined in AMF's prototype shop in Stamford. The fiberglass case was built on a split mandrel and the bottom section was molded separately as was the top section. They were then bonded together to form the main part of the case. The cap was formed in a similar fashion. All the fiberglass sections were made in AMF's laboratory. Several detail changes were made in the bayonet connection between the cap and the case to facilitate the manufacture.

The nylon balls used in the locking mechanism were changed to include a circumferential groove to improve the joints capacity in torsion. A notch was provided in the groove of the tube to provide a positive lock for the release mechanism.

Testing of the mast started in January 1964. Two-hundred erection cycles were completed without wear which would affect its operation. Temperature tests were performed and passed. The static load test (Figures 3 and 4) was performed without failure. This test simulated a 70 mph wind with dead load and top load as required for survival.

The test program was completed on the preliminary test model. The following tests were satisfactorily completed:

1) Examination of product
2) Cycling tests
3) Static Test - survival load
4) Temperature test
5) Moisture resistance test
6) Sand and dust
7) Torsion test

The following tests were satisfactory in varying degrees:

1) Erection Time Test
2) Bounce Test
3) Shock Test

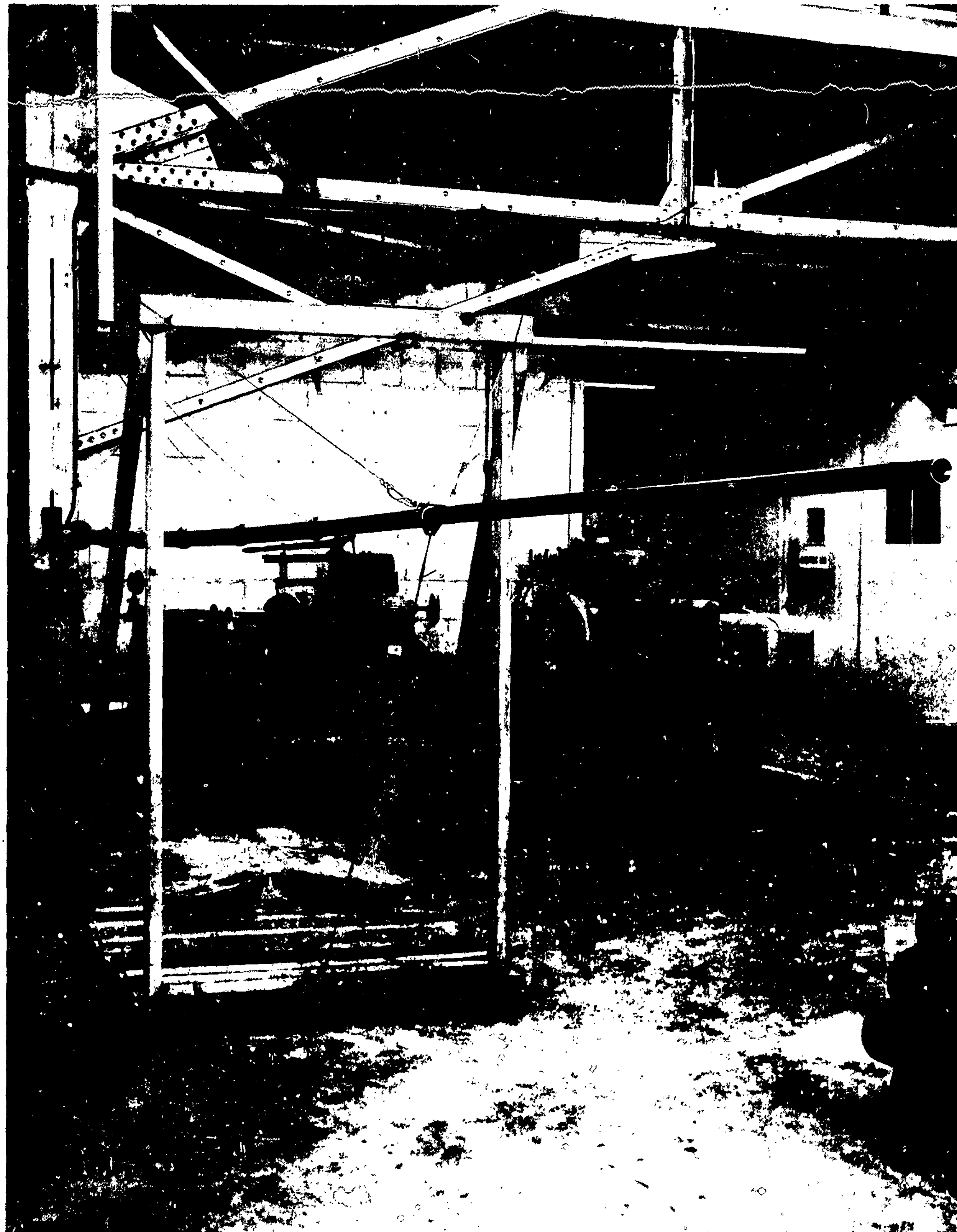

Figure 3. Survial Test Setup

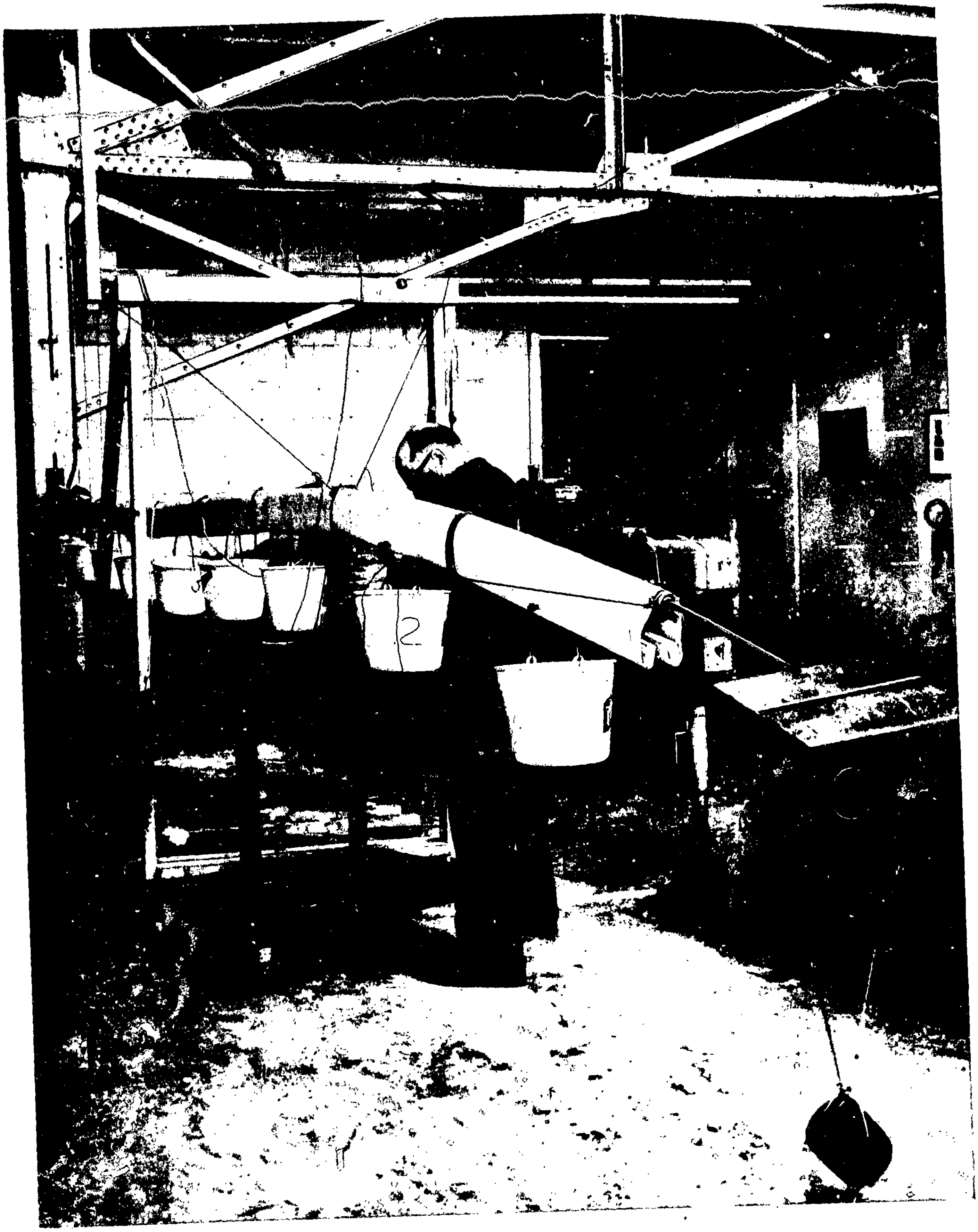

Figure 4. Survial Load Applied

Requirements for the erection time test were not met due to friction at the joints under wind load. Best time measured was 12 minutes. This could have been improved with practice, but the telescopic mast is inherently difficult to extend when a moment load is applied to the joint.

The bounce test and shock test showed that the thin material required in the aluminum tubes, to provide a lightweight structure, was not strong enough to withstand abuse at the formed end. Because of this, a major change was made which incorporates a fiberglass reinforcing sleeve on the end of the tubes where the locking mechanism is located. The actuator buttons also broke.

Various changes in details which appeared necessary as a result of the tests were incorporated into the design of the three engineering test models. One model was subjected to a three-hour bounce test to demonstrate the effectiveness of the changes. This model passed the test satisfactorily.

Several items were changed as a result of the test and incorporated into the three engineering models; the clip holding the shoulder strap was redesigned without projections and the base of the case was redesigned without projections and the base of the case was reinforced.

The three engineering test models passed inspection, which included an erection, and were delivered to the customer.

5. CONCLUSIONS.

The results of the tests indicated:

1) Reinforcement is necessary at the formed ends of the tubes.
2) Projections will not stand up under bounce test. Strap clips had to be changed.
3) The actuator buttons had to be redesigned to obtain more strength in the connection to the spring.
4) A three-minute erection time could not be obtained with the present design.

6. OVERALL CONCLUSIONS.

Conclusions:

1) A 30 foot guyed mast with its case can be built from aluminum and fiberglass and weigh less than 20 pounds.
2) A telescopic mast is difficult for 1 man to erect in a 20 mph wind when it is higher than 22 feet.
3) A telescopic mast resists extension under wind load in proportion to the wind velocity. A mast which can be easily extended with no wind acting, resists the efforts of 2 men in winds about 20 mph due to a wedging action and friction between the mating sections.
4) An aluminum-fiberglass structure can be very effective when the materials can be located to take advantage of their inherent properties.

7. RECOMMENDATIONS.

While every effort has been made to optimise the design of the 30 foot mast, there are still areas for improvement. If a production program were instituted, the mast could be product engineered for lighter weight, lower cost, and smoother operation.

As fiberglass technology improves and higher moduli of elasticity are available, the all fiberglass mast will be more competitive to aluminum with respect to light weight construction. It would be desirable to design, build and test at least one all fiberglass mast of the same general configuration as the mast discussed herein.

8. RESUMES

Resumes of the key personnel who have worked on this project follow this page.

LEWIS V. SMITH, Jr.

Assistant Manager, Antenna Systems Products

SPECIALTIES

Mr. Smith has 17 years' experience as a structural engineer and engineering project manager on a number of commercial and Government programs, with emphasis on radar projects.

EXPERIENCE

AMF. Mr. Smith joined AMF in 1960 as project manager in charge of radar antenna programs. He is now advisor on all radar systems proposals and project manager for major radar systems efforts within the Antenna Systems Department. He is advisor on new technical approaches and establishes new radar concepts. Recently, Mr. Smith served as project engineer, deputy project manager and project manager on the Mobile Atlantic Range Station antenna system (MARS-ARIS) and 30 foot lightweight Telescopic mast.

General Bronze Corporation. Mr. Smith served as structural engineer, assistant chief mechanical engineer and chief structural engineer. He conceived and designed parabolic reflectors, cosecant squared reflectors, and managed systems which included reflectors, pedestals, servo-controlled systems, and field installations. He was responsible for determination of loads, choice of allowable stresses and applicable codes determination of deflectrons and natural frequency of structures. He contributed to the following projects: 60-foot steerable antennas; CCM Mark I, 120-foot antenna, for Lincoln Laboratories; Tiros steerable array, for RCA; and 250 parabolic antennas designed for Space Tehnology Laboratories.

Edwards & Hjorth. As structural engineer, Mr. Smith designed and supervised construction of towers, tunnels and tall structures, including the TV tower atop the Empire State Building.

EDUCATION

BS	Cooper Union	Civil Engineering
MS	Polytechnic Institute of Brooklyn	Civil Engineering

PROFESSIONAL ACTIVITIES

American Society of Civil Engineers
Sigma Xi
Professional Engineer, State of New York

GEORGE F. CANADE

Design Group Supervisor,
Radar Systems Section

SPECIALTIES

Mr. Canade has more than 30 years' experience in the design and development of radar systems, nuclear materials handling equipment, boosters, rocket motors, electro-mechanical devices, automatic machinery and guided missiles ground handling equipment and facilities.

EXPERIENCE

AMF. Mr. Canade joined AMF in 1957. As design group supervisor, he is responsible for design of radar systems and electro-mechanical devices. He has been in charge of programs for precision instrument mounts, the AN/TPQ-10 Radar, the SCR-270 Radar Antenna, and electro-mechanical components for the Titan and Atlas missile launcher systems. He has contributed to the development of automatic machinery and processing plants and has served as liaison engineer to manufacturing.

Burns and Roe, Inc. As design engineer and design supervisor, Mr. Canade determined material specifications and vendor design, and worked on Bomarc missile and facilities handling equipment designs.

Combustion Engineering, Inc. Mr. Canade was employed as a design Engineer and design section supervisor responsible for commercial and naval nuclear systems and their related specialized maintenance equipment.

Design Service Company. Mr. Canade was a project and design engineer, responsible for the design and development of remotely operated automatic welding machinery.

M. W. Kellogg Company. As design engineer, Mr. Canade designed and developed rocket motor fuel injectors, machining fixtures for booster fabrication, and various types of test rigs and fixtures.

LEWIS W. BENNETT

Human Factors Engineer,
Engineering Directorate

SPECIALTIES

Mr. Bennett has more than 11 years' experience in human factors engineering and industrial design, in both commercial and military fields.

EXPERIENCE

AMF. Mr. Bennett joined AMF in 1958. As human factors engineer, he specializes in design improvement through the application of human factors criteria to man-machine analyses and systems. He has contributed to the Titan and Atlas Launcher System programs, Nerva and Candu systems, communications' control centers, and other electro-mechanical systems.

Peter Cherry, Inc. As an industrial designer and prototype analyst, Mr. Bennett designed consumer products, including high fidelity recording systems, hair dryers, perfume dispensers and toys.

Henry Dreyfuss, Inc. As an industrial designer, Mr. Bennett contributed to human factors engineering efforts for U. S. Army tanks, Gradall operator's cabs, and visual-control panels for several industrial and military products and systems.

Richard Arbib Company, Inc. Mr. Bennett designed consumer products, including vacuum cleaners, furnaces, automotive equipment, watches and allied items.

Dunlap and Associates. Mr. Bennett was in charge of visual presentations and design.

EDUCATION

BFA	Rhode Island School of Design	Industrial Design
	Brown University	Engineering

PROFESSIONAL ACTIVITIES

Human Factors Society
Author of several ASTIA papers on Human Factors Engineering and Evaluation

SIMON I. GLASSMAN

Senior Engineer,
Quality Assurance Directorate

SPECIALTIES

Mr. Glassman has more than 20 years' experience in systems engineering and management, operations and economic analysis, design, development, and testing of mechanical, electro-mechanical and hydraulic equipment.

EXPERIENCE

AMF. Mr. Glassman joined AMF in 1960. In his present assignment, he determines the quality assurance requirements for systems programs within the engineering laboratories. Previously, Mr. Glassman was assigned as a test engineer on the spares effort of the Atlas Silo-Lift Launcher program. On the Mobile Minuteman program, he was test section representative at the Change Board and Project Meetings. He reviewed project hardware and prepared design evaluation reports, was test conductor for components and systems tests, and participated in the planning requirements in the preparation of tests, fixtures, reports, estimates and proposals for the design evaluation, pre-production, and acceptance test phases of the program.

Bogart Manufacturing Company. Mr. Glassman was assistant to the chief engineer, responsible for equipment design reviews, debugging of prototype and production components and assemblies, liaison with the production, quality control, and purchasing departments on microwave components and equipment.

Nuclear Development Corporation. Mr. Glassman participated in various programs relating to the engineering design of power generating nuclear reactors.

Penn-Texas Corporation. As chief development engineer, Mr. Glassman was responsible for the project direction, research, development, design and economic evaluation of highly complex systems and equipment.

EDUCATION

BMD	City College of New York	Mechanical Engineering
MME	New York University	Mechanical Engineering
MBA	City College of New York	Industrial Management

PROFESSIONAL ACTIVITIES

Professional Engineer, State of New York
New York State Society of Professional Engineers
American Ordnance Association
Society of American Military Engineers

PAUL A. MASON

Manager, Value Engineering Department
Engineering Directorate

SPECIALTIES

Mr. Mason has more than 14 years' experience in all phases of mechanical and hydraulic system design as applied to weapons systems, including specialized experience in cost reduction and value analysis.

EXPERIENCE

AMF. Mr. Mason jointed AMF in 1960. Currently, he is Value Engineering Manager of the York Division reporting to the Engineering Directorate and performing value analysis on all projects. Previously, he served as supervisor of the value engineering and safety group of the SEL Engineering Department. Mr. Mason's first AMF responsibility was as assistant to the Chief project engineer in charge of the safety program on the Atlas silo missile lift system.

Republic Aviation Corporation. As a principal engineer, hydro-mechanical group, Mr. Mason was responsible for the design of hydraulic and mechanical control systems for the RF84F and F105 aircraft. As part of his duties, he supervised flight tests of hydro-mechanical systems. Mr. Mason was also engaged in the F105 cost reduction program and was a member of the value analysis committee. While on special assignment, he conducted materials research for an ultra-high-temperature hydraulic system research and development program.

Republic Missiles Division. Mr. Mason was responsible for the design review of mechanical systems for earth satellites (antenna erection systems and other supporting mechanisms) while on loan to this Division.

EDUCATION

Sydney Technical College (Australia)	Architectural Engineering
Alexander Hamilton Institute	Business Administration
New York University	Advanced Hydraulic Theory & Desig
Republic Staff Training School	Hydraulic Systems Design

PROFESSIONAL ACTIVITIES

Member, Society of American Value Engineers
Life Member, National Rifle Association

PAUL A. MASON

Manager, Value Engineering Department
Engineering Directorate

SPECIALTIES

Mr. Mason has more than 14 years' experience in all phases of mechanical and hydraulic system design as applied to weapons systems, including specialized experience in cost reduction and value analysis.

EXPERIENCE

AMF. Mr. Mason jointed AMF in 1960. Currently, he is Value Engineering Manager of the York Division reporting to the Engineering Directorate and performing value analysis on all projects. Previously, he served as supervisor of the value engineering and safety group of the SEL Engineering Department. Mr. Mason's first AMF responsibility was as assistant to the Chief project engineer in charge of the safety program on the Atlas silo missile lift system.

Republic Aviation Corporation. As a principal engineer, hydro-mechanical group, Mr. Mason was responsible for the design of hydraulic and mechanical control systems for the RF84F and F105 aircraft. As part of his duties, he supervised flight tests of hydro-mechanical systems. Mr. Mason was also engaged in the F105 cost reduction program and was a member of the value analysis committee. While on special assignment, he conducted materials research for an ultra-high-temperature hydraulic system research and development program.

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Alexander Hamilton Institute	Business Administration
New York University	Advanced Hydraulic Theory & Design
Republic Staff Training School	Hydraulic Systems Design

PROFESSIONAL ACTIVITIES

Member, Society of American Value Engineers
Life Member, National Rifle Association

JOHN LIONETTI

Manufacturing Engineer,
Manufacturing Directorate

SPECIALTIES

Mr. Lionetti has 25 years' experience in manufacturing engineering and in tool and die and precision machinery development.

EXPERIENCE

AMF. Mr. Lionetti joined AMF in 1956. As manufacturing engineer, he is assigned to estimating and cost analysis of new programs, development of production procedures and determination of the application of skills and equipment. Previously, he had responsibility for the installation of the APES prototype and training facility at Vandenberg, AFB. During the Titan launcher system program, he served as a manufacturing engineer on launcher system drive power units, and was AMF subcontractor representative at the Falk Corporation. From mid-1959 to early 1961, he was assigned to production of the Atlas launcher prototype and operational drive power units. For the remainder of 1961 and 1962, he served as Titan launcher installation engineer at Complex 1A for the Titan Denver Division. He joined AMF as a manufacturing engineer assigned to refueling units for the Triton and Sea Wolf submarines.

Diebold, Inc. As an experimental development engineer, Mr. Lionetti assisted in developing prototype microfilm cameras and film readers.

Kalart, Inc. As assistant chief engineer, he was responsible for production and quality assurance for several camera equipment projects.

Winchester Electronics Corp. Mr. Lionetti was a tool and die maker.

EDUCATION

New York University — Methods Engineering

ROBERT J. MURPHY

Reliability Engineer
Quality Assurance Directorate

SPECIALTIES

Mr. Murphy has 10 years' experience in the design, development, and evaluation of electronic and electro-mechanical equipment with emphasis in reliability and human factors engineering.

EXPERIENCE

AMF. Mr. Murphy joined AMF in 1961. He is responsible for reliability analyses and reliability engineering on a variety of programs, including airborne handling equipment, blast valves, and ground support equipment. He was responsible for a comprehensive malfunction analysis of the Titan Launcher System and was responsible for the man-machine analyses of that program and also the Mobile Minutemanprogram. At Vandenberg AFB, he participated in the Titan personnel subsystem test and evaluation program to determine the capability of military personnel to operate, control, and maintain the system safely.

Dunlap and Associates. As a member of the Human Factors Engineering Division, Mr. Murphy participated in the human factors analysis of the Navy's Polaris weapon system. This work included evaluations of the operating and maintenance procedures for the navigation, ship control, and fire control subsystems. He worked with personnel at the Sperry Marine Divison of Sperry Rand Corporation on the design of a computer facility to simulate the navigation subsystem. He prepared chapters for the Human Factors Guide for the Fleet Ballistic Missile System on the design of controls and the design of electronic equipment maintainability.

Norden Laboratories. Mr. Murphy was responsible for the integration of the Norden TV system with other equipment on the B-58 aircraft. He also prepared panel designs for radar test equipment, and formulated procedures for the reliability testing of electronic components.

Arma. Mr. Murphy designed control and computer circuitry on projects for the AEC and the U. S. Air Force.

EDUCATION

BS	Columbia University	Electrical Engineering
MBA	City College of New York	Industrial Management for Engineers

DAVID BIDERMAN

Test Engineer
Quality Assurance Laboratory

SPECIALTIES

Mr. Biderman has more than 16 years' experience in test engineering, including test planning, implementation, instrumentation, and data reduction.

EXPERIENCE

AMF. Mr. Biderman joined AMF in 1956. He was test supervisor on the Atlas spare parts test program, responsible for test planning test specifications, test implementation, and estimating test costs. Mr. Biderman also prepared test requirements for the Titan launcher system, conducted development tests on Titan components and performed a liaison function with the AMF Buffalo facility. He prepared test plans, supervised instrumentation and data reduction on GAM-72 launch gear project at the Steamboat Road Laboratory, Greenwich. Mr. Biderman was test manager at Aberdeen Proving Grounds, concerned with cold chamber demonstration tests on GAM-72 launch gear. He was also responsible for design of a modular cold chamber capable of accepting Talos launch equipment.

Chance-Vought Aircraft. Mr. Biderman prepared flight test plans, summarized test results, conducted ground test and prepared reports on test results. These tests were conducted on the F4U-1, F4U-4, XF5U-4 and V-173 aircraft.

Edo Corporation. While at Edo Corporation, Mr. Biderman conducted preliminary flight test demonstrations for the Navy Bureau of Aeronautics on XOSE-1, XOSE-2, and XTE-1 aircraft. He supervised flight planning, instrumentation, data reduction, and test reports.

East Coast Aeronautics. Mr. Biderman was design test engineer, responsible for design, development and testing of airframes and functional mechanical aircraft parts. He was lead man on an Army Ordnance rocket development program and a reinforced plastic missile airframe development program.

EDUCATION

BAE	New York University	Aeronautical Engineering

THOMAS A WICKENHAVER

Manufacturing Engineer,
Manufacturing Department

SPECIALTIES

Mr. Wickenhaver has eight years' experience in the field of method, design and development techniques, and in production of multi-channel R-F rotary joints, complex machines, and electro-mechanical components.

EXPERIENCE

AMF. Mr. Wickenhaver joined AMF in 1957. As a manufacturing engineer, he has aided in advancing the following projects from the jury rig, or prototype to the production stage. AN/TPQ-10 antenna, AN/FPS-24 four-channel rotary joint, and the closure door complex for Titan silo installation. He was the group leader in the erection of the modified SCR-270 radar system at Eglin Air Force Base, Florida. His responsibilities also have included the techniques involved in the design of single channel rotary joints and fabrication of new type microwave components.

AVCO Manufacturing Corporation, Advance Research & Development Division. Mr. Wickenhaver was instrumental in the development of manufacturing techniques used in the fabrication of nose cones for the Titan ICBM.

United States Coast Guard. Mr. Wickenhaver has experience of various types of riggings for the handling and placing of navigation aids (markers and buoys) and heavy cargo handling. He also has experience as an instructor for boatswain's mate, petty officer training.

Grumman Aircraft Corporation. As a designer, Mr. Wickenhaver's responsibilities included the design and fabrication of aircraft lofting and templates for the construction of aircraft components.

EDUCATION

AAS	New York State University Attended Hofstra College	Mechanical Engineering

PROFESSIONAL ACTIVITIES

Senior Member, American Society of Tool and Manufacturing Engineers
Member, New York State University Curriculum Advisory Committee

AD ______________________ And Accession ______________________

American Machine & Foundry Company, Advanced Products Group, York, Pennsylvania

Final Report, 1 July 1963 - 30 June 1964, 30 Foot Lightweight Telescopic Mast, Phase I, II, III

By Lewis V. Smith, Jr.

26 Pages, 4 figures

Contract No. DA-36-039-AMC-03309(E)

A preliminary engineering test model of a 30 Foot Lightweight Telescopic Mast has been built and tested. Modifications, based on test results, have been made to the design and the engineering test models. The final weight of the mast is approximately 19.5 lbs. The mast is capable of erection by 2 men in a 20 mph wind, and with the base stabilized it can be erected by 1 man.

Conclusions:

1. A 30 ft. guyed mast with its case can be built from aluminum and fiberglass and weigh less than 20 lbs.

2. A Telescopic Mast is difficult for 1 man to erect in a 20 mph wind when it is higher than 22 ft.

3. A Telescopic Mast resists extension under wind load in proportion to the wind velocity. This mast, which can be easily extended with no wind acting, resists the efforts of 2 men in winds about 20 mph due to a wedging action and friction between the mating sections.

4. An aluminum-fiberglass structure can be very effective when the materials can be located to take advantage of their inherent properties.

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